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(71)Applicant : NIPPON STEEL CORP
(72)Inventor : UCHINO KOICHI
KARIMINE KENICHI

## (54) MANUFACTURING METHOD OF RAIL WITH HIGH WEAR RESISTANCE AND HIGH TOUGHNESS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a manufacturing method of a rail of high toughness, in which the growth of re-crystallized grain $\gamma$ during and after rolling is suppressed, a pearlite structure of the grain is obtained, and the toughness is provided in the steel representing pearlite structure with high carbon content of excellent strength and wear resistance.
SOLUTION: In this manufacturing method of a rail of high wear resistance and toughness representing pearlite metal structure, a steel slab containing, by mass, 0.6-1.20% C and other alloy elements is subjected to rough rolling, and the intermediate rolling is performed by a reverse rolling mill at the surface temperature between 900 and 1,050°C. Next, the finish rolling is performed by a continuous rolling mill at the surface temperature between 850 and 1,000°C with at least two passes of reduction ratio per pass of 5-30% and ≤10 seconds between rolling passes. After the rolling, the steel slab is cooled to 800-950°C at the cooling speed of 0.5-50°C/s on the rail surface, and subjected to the natural or accelerated cooling.

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## CLAIMS

[Claim(s)]
[Claim 1]After rough-rolling slab which contains C:0.6 to 1.20% by mass %, while skin temperature is 900-1050 **, perform middle rolling by a reverse rolling machine, and while skin temperature is 850-1000 **, continuously finishing rolling by a continuous mill, Are more than a two pass about rolling whose reduction of area is 5 to 30% per one pass, and between rolling passes is given as 10 or less seconds, A manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture cooling to 800-950 ** and cooling radiationally after that after rolling with a cooling rate at 0.5-50 **/s in a rail surface.
[Claim 2]An ingredient of slab is C at mass %. : 0.6 to 1.20%, Si:0.10-1.20%, Mn: A manufacturing method of high abrasion proof and a high toughness rail which presented the perlite metal texture according to claim 1 characterized by the remainder consisting of Fe and inevitable impurities including 0.40 to 1.50%.
[Claim 3]A manufacturing method of high abrasion proof and a high toughness rail in which an ingredient of slab presented the perlite metal texture containing Cr:0.05-2.00%, Mo:0.01-0.30%, and Co:0.10-2.00% of one sort, or two sorts or more according to claim 2 further by mass %.
[Claim 4]A manufacturing method of high abrasion proof and a high toughness rail in which an ingredient of slab presented the perlite metal texture containing Cu:0.05-2.00% and nickel:0.05-2.00% of one sort, or two sorts according to claim 2 or 3 further by mass %.
[Claim 5]An ingredient of slab is V further at mass %. : 0.01 to 0.30%, Nb : [ 0.002 to 0.050%, ] Ti: 0.005-0.100%, Ca:0.0005-0.0100%, Mg: A manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture of a statement to any 1 paragraph of claims 2 thru/or 4 containing 0.0005 to 0.0100% of one sort, or two sorts or more.

[Claim 6]A manufacturing method of high abrasion proof and a high toughness rail which

presented a perlite metal texture of a statement to any 1 paragraph of claims 1 thru/or 5 cooling in s in 2-15 ** /, and cooling radiationally between from temperature of not less than 700 ** to 500 ** after that succeedingly after cooling a rail surface to 800-950 **.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the manufacturing method of the high toughness rail which gave toughness to the intensity used as an object for a railroad and other industrial machines, and the steel which presented the pearlite texture of high carbon excellent in abrasion resistance.
[0002]
[Description of the Prior Art]Since the steel which presented the metal texture of perlite with high carbon has high intensity and abrasion resistance is good, it is used as a structural material, and corresponding to a raise in axial load and rapid-transit-izing which are especially followed on the weight increment of a rail car, many rails are used especially.
[0003]As a manufacturing method of such steel materials, it is steel of the specific component which is easy to present JP,55-276,A "pearlite texture, for example Ac3 Cool from the cooking temperature beyond a point and isothermal transformation is carried out at the temperature of 450-600 **, To the manufacturing method of the hard rail which makes a fine pearlite organization generate", and JP,58-221229,A. "C: 0.65-0.85%, Mn : Mn steel rails which contained 0.5 to 2.5% and held the heat of high temperature are quenched, To the heat treatment method of the rail which has improved abrasion resistance by making the organization of a rail or a rail head into detailed perlite", and also JP,59-133322,A. "The rolling rail of a specific component with which it is stabilized and pearlite texture is obtained is immersed into the fused salt bath of specific temperature from the temperature of three or more Ar(s), Much art is known as the heat treating method of the rail which presents the detailed pearlite texture which has the hardness of Hv>350 by about 10 mm under the rail parietal region surface" is indicated.
[0004]However, although a necessary standard item is easily obtained by addition of an alloy

element, the intensity and abrasion resistance of pearlitic steel, Toughness is remarkably low as compared with the steel which made the ferrite the subject, for example, it is JIS No. 3 with perlite rail steel. It is about 10-20 N.m in the ordinary temperature test value in U notch Charpy test. Thus, when steel with low toughness was used as a structural member in the field which a repeated load and vibration require, there was a problem of causing a low stress brittle fracture from minute initial defects or a fatigue crack.

[0005]In order to raise the toughness of steel generally, it is called what is attained by the minuteness making of a metal texture, i.e., grain refining of an austenite texture, and grain domestic disturbance voice. The combination of controlled rolling and heat-treatment, the low-temperature reheating process after rolling, etc. are used as grain refining of the austenite texture is indicated by low-temperature heating at the time of rolling, or JP,63-277721,A, for example.

[0006]However, in the manufacturing method of a rail, from a viewpoint of moldability reservation, since application of low-temperature heating at the time of rolling, low-temperature rolling in controlled rolling, and large pressing-down rolling is difficult, also in today, improvement in the toughness by the low-temperature reheating process from the former is achieved. However, this method also has problems, like while development of the laborsaving and productivity drive art in each steel part of late is furthered, the manufacturing cost of productivity is highly low, and these early development is desired.

[0007]

[Problem(s) to be Solved by the Invention]This invention tends to cancel the above-mentioned problem.

The purpose is to provide the method of conquering the problem of the controlled rolling which low temperature or large pressing down therefore required on rail shaping, performing controlled rolling peculiar to eutectoid steel, and raising the toughness of eutectoid carbon steel, such as rail steel.

[0008]

[Means for Solving the Problem]In order that this invention persons may manufacture steel which obtained pearlite texture of a fine grain and raised toughness, As a result of trying many experiments from a steel composition and its manufacturing method, steel of high carbon near eutectoid carbon steel is low temperature comparatively in processing in the austenite state, And the knowledge of finding out also recrystallizing a small rolling draft immediately after rolling, acquiring a detailed austenite grain of a particle size regulation by continuous rolling of small pressing down, and as a result pearlite texture of a fine grain being obtained was carried out. However, a detailed recrystallization austenite grain immediately after rolling had large grain growth between rolling passes, and the knowledge also of also having influence of [ to

the extent that an effect of rolling with each path is offset ] was carried out.
[0009]The place which constitutes this invention based on such knowledge, and is made into the gist is as follows.
(1) After rough-rolling slab which contains C:0.6 to 1.20% by mass %, while skin temperature is 900-1050 **, perform middle rolling by a reverse rolling machine, and while skin temperature is 850-1000 **, continuously finishing rolling by a continuous mill, Are more than a two pass about rolling whose reduction of area is 5 to 30% per one pass, and between rolling passes is given as 10 or less seconds, A manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture cooling to 800-950 ** and cooling radiationally after that after rolling with a cooling rate at 0.5-50 **/s in a rail surface.
(2) An ingredient of slab is C at mass %. : Manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture of the aforementioned (1) statement characterized by the remainder consisting of Fe and inevitable impurities including 0.6 to 1.20%, Si:0.10-1.20%, and Mn:0.40-1.50%.
(3) slab -- an ingredient -- mass -- % -- further -- Cr -- : -- 0.05 - 2.00 -- % -- Mo -- : -- 0.01 - 0.30 -- % -- Co -- : -- 0.10 - 2.00 -- % -- one -- a sort -- or -- two -- a sort -- more than -- containing -- things -- the feature -- carrying out -- the above -- (-- two --) -- a statement -- perlite -- a metal texture -- having presented -- high -- abrasion proof - a high toughness rail -- a manufacturing method .
(4) A manufacturing method of high abrasion proof and a high toughness rail in which an ingredient of slab presented a perlite metal texture of a statement further to the above (2) to which it is characterized by containing Cu:0.05-2.00% and nickel:0.05-2.00% of one sort, or two sorts, or (3) by mass %.
(5) An ingredient of slab is V further at mass %. : 0.01 to 0.30%, Nb: 0.002-0.050%, Ti : 0.005 to 0.100%, Ca: 0.0005-0.0100%, Mg: A manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture of a statement to the above (2) containing 0.0005 to 0.0100% of one sort, or two sorts or more thru/or any 1 paragraph of (4).
(6) After cooling a rail surface to 800-950 **, between from temperature of not less than 700 ** to 500 ** is succeedingly cooled in s in 2-15 ** /, A manufacturing method of high abrasion proof and a high toughness rail which presented a perlite metal texture of a statement to the above (1) cooling radiationally after that thru/or any 1 paragraph of (5).
[0010]
[Embodiment of the Invention]Hereafter, this invention is explained in detail. First, the reason which limited the steel composition as mentioned above in this invention is explained. 0.60% or more of content is required for C as an effective ingredient which makes pearlite texture generate and secures abrasion resistance. However, although it deposits mostly and hardness increases a cementite organization in the high content exceeding 1.20%, ductility falls and

reduces remarkably the toughness which is the purpose of this invention.
[0011]Since this invention is based on the knowledge of the austenite recrystallization action peculiar to steel containing carbon near [ above at least ] the eutectoid point, even if it adds various alloys if needed, in the range which a metal texture presents perlite, it is inoffensive in any way. For this reason, the following alloy elements can be suitably added for the purpose of raising intensity, and ductility and toughness.
[0012]Although Si is an element which raises the hardness (intensity) of a rail head by the solid solution hardening to the ferrite phase in pearlite texture, At less than 0.10%, since weldability would fall by that many surface flaws generate at the time of hot-rolling, and generation of an oxide if the effect cannot fully expect and exceeds 1.20%, the amount of Si was limited to 0.10 to 1.20%.
[0013]Mn reduces pearlitic transformation temperature and contributes to high intensity-ization by improving hardenability, further, although it is an element which controls generation of a free cementite organization, by less than 0.40% of content, the effect is small and it becomes difficult to secure it of the hardness needed for a rail head. Since hardenability would increase remarkably, becoming easy to generate martensitic structure and a segregation would be promoted and it would become easy to generate a free cementite organization harmful to the toughness of a rail to a segregation part if it exceeds 1.50%, the amount of Mn was limited to 0.40 to 1.50%.
[0014]Are an element which raises abrasion resistance by strengthening the cementite phases in pearlite texture at the same time Cr raises the balanced transformation point of perlite, it makes pearlite texture detailed as a result and it contributes to high intensity-ization, but. At less than 0.05%, if superfluous addition in which the effect is small and exceeds 2.00% is performed, in order for martensitic structure to generate so much and to reduce the toughness of a rail, the amount of Cr(s) was limited to 0.05 to 2.00%.
[0015]Although it is an element which Mo raises the balanced transformation point of perlite like Cr, and contributes to high intensity-ization and raises abrasion resistance by making pearlite texture detailed as a result, At less than 0.01%, since a segregation was promoted, pearlitic transformation speed fell further, martensitic structure would generate to a segregation part and the toughness of a rail would fall to it if superfluous addition in which the effect is small and exceeds 0.30% is performed, the amount of Mo was limited to 0.01 to 0.30%.
[0016]Although it is an element which Co makes the transformation energy of perlite increase and raises intensity by making pearlite texture detailed, At less than 0.10%, since the effect arrived at a saturation region even if it performs superfluous addition which cannot expect the effect and exceeds 2.00%, the amount of Co(es) was limited to 0.10 to 2.00%.
[0017]Cu was an element which does not spoil the toughness of pearlitic steel but raises intensity, and if the effect was the largest in 0.05 to 2.00% of range, and it exceeded 2.00%,

since it would become easy to produce red heat embrittlement, it limited the amount of Cu(s) to 0.05 to 2.00%.
[0018]Although it is an element which raises the ductility of pearlitic steel, and toughness as for nickel, and attains high intensity-ization of pearlitic steel by solid solution strengthening simultaneously, at less than 0.05%, the effect is remarkably small, and even if it performs superfluous addition exceeding 2.00%, the effect beyond it is not expectable. Therefore, the amount of nickel was limited to 0.05 to 2.00%.
[0019]Although it is an element which raises the hardness inside a head by V's forming carbide and a nitride inside a rail head with a slow cooling rate in heat treatment of a rail head as compared with a heading part, and depositing on the ferrite background in pearlite texture, At less than 0.01%, formation of carbide or a nitride becomes difficult and precipitation hardening of the pearlite texture inside a rail head becomes difficult. Since the effect beyond it was not expectable even if it adds exceeding 0.30%, the amount of V was limited to 0.01 to 0.30%.
[0020]Nb raises intensity by precipitation hardening by Nb carbide and Nb nitride like V, Carrying out minuteness making of the austenite grain by the operation which controls grain growth, when heat treatment heated to high temperature is performed, rather than V, the austenite grain growth depressor effect acts to a high temperature region (about 1200 **), and improves the ductility of pearlite texture, and toughness. At less than 0.002%, even if the effect performs superfluous addition which cannot expect and exceeds 0.050%, it cannot expect the effect beyond it. Therefore, the amount of Nb(s) was limited to 0.002 to 0.050%.
[0021]Ti is an ingredient effective in attaining minuteness making of the austenite crystal grain at the time of rolling heating, and raising the ductility of pearlite texture, and toughness using depositing Ti carbides and Ti nitrides not dissolving, in rail pressure Nobutoki's reheating. However, at less than 0.005%, there were few the effects, and if it adds exceeding 0.100%, in order for big and rough Ti carbides and Ti nitrides to generate, to become a starting point of fatigue damage rail in use and to generate a crack, Ti quantity was limited to 0.005 to 0.100%.
[0022]Associative strength of Ca with S which is inevitable impurities is strong, and it forms a sulfide as CaS, It is an element effective in raising the ductility of pearlite texture, and toughness by CaS's distributing MnS minutely, forming the thin belt of Mn in the circumference of MnS, contributing to generation of a pearlitic transformation, and as a result carrying out minuteness making of the perlite block size. However, at less than 0.0005%, the effect was weak, and if it adds exceeding 0.0100%, in order for the big and rough oxide of Ca to generate and to degrade the ductility of a rail, and toughness, it limited the amount of Ca to 0.0005 to 0.0100%.
[0023]Mg is an element effective in combining with O or S, aluminum, etc., forming a detailed oxide, controlling the grain growth of a crystal grain in rail pressure Nobutoki's reheating, attaining minuteness making of an austenite grain, and raising the ductility of pearlite texture,

and toughness. It is an element effective in raising the ductility of pearlite texture, and toughness by MgOMgS's distributing MnS minutely, forming the thin belt of Mn in the circumference of MnS, contributing to generation of a pearlitic transformation, and as a result carrying out minuteness making of the perlite block size. However, at less than 0.0005%, the effect was weak, and if it adds exceeding 0.0100%, in order for the big and rough oxide of Mg to generate and to degrade rail ductility and toughness, it limited the amount of Mg to 0.0005 to 0.0100%.

[0024]Next, each process condition of this invention is explained. In rolling of rail steel, the rolling draft per one pass of the middle rolling stage after performing rough form rolling of a cast piece, and a finishing rolling stage is made into the reduction of area from a viewpoint of moldability reservation of a rail, and is usually 5 to 30% of comparatively small range, and finishing temperature is about 1000 **. On the other hand, it rolls at low temperature more these days, and controlled rolling aiming at an improvement of ductility and toughness is also performed. In the case of, in the case of the controlled rolling of the steel which generally made the ferrite the subject, rolling temperature is reduced to the unrecrystallized field of austenite, and the controlled rolling method for aiming at increase of a ferrite nucleus and obtaining a fine grain ferrite by introduction of a strain into processing austenite, is taken.

[0025]However, it turned out that the growth rate of perlite is large because of eutectoid transformation in the case of pearlitic steel, and the transformation core within an austenite grain does not act effectively, but fine grain perlite is hard to be obtained substantially. Therefore, it turned out that it is required for perlite grain refining to obtain the fine grain austenite of a particle size regulation.

[0026]From this viewpoint, as a result of examining the recrystallization action of the austenite of high carbon steel in detail, as compared with 1 low carbon steel to a low temperature, that the time which perfect recrystallization takes after recrystallizing in low workability and 2 processings is dramatically small, namely, completes recrystallization immediately after rolling and 3 -- if small pressing down also adds processing continuously (about 10 or less seconds), recrystallization will be repeated each time and the grain growth to the next processing will be controlled. [ and ] Or since the grain growth to which after-rolling temperature is reduced also between the paths for 10 seconds or more was controlled, the knowledge of the recrystallization austenite grain of a ready fine grain being acquired was carried out.

[0027]The optimal processing-conditions range was found out based on these knowledge. The reason for limitation of conditions is explained below. Although the austenite of a fine grain is obtained by the recrystallization according to the reduction of area after each rolling pass in the case of middle rolling by a reverse rolling machine, since it is reverse rolling, the time between paths will be 20 to 60 seconds, and its grain growth in the meantime is specifically remarkable. Then, by the temperature of middle rolling being 900-1050 **, grain growth can be controlled,

accumulation of the detailed austenite grain in each path is obtained, and grain refining of the austenite grain before finishing rolling can be attained. Although passing time in particular is not specified, usually two to 3 path performs for every path, considering the required reduction of area.

[0028]About finishing rolling temperature, the range of 850-1000 ** is the optimal, and as austenite will be in the state where it does not recrystallize, at less than 850 ** and it stated previously, it is not effective in the minuteness making of perlite. On the other hand, when exceeding 1000 **, it is large, and the austenite grain growth after rolling serves as coarse-grain austenite of a mixed grain size at the time of a pearlitic transformation, and is not effective in the minuteness making of perlite. Since skin temperature rises according to the recuperation from the inside of a rail before finishing rolling after middle rolling, it is usually preferred to adjust finishing temperature with cooling or radiational cooling suitably.

[0029]About the rolling reduction per one pass, 5 to 30% of range is the optimal, less than 5% of case is effective in recrystallization, when introduction of a strain effective in making recrystallization reveal cannot be performed and it exceeds 30%, but. It is not effective from that it becomes impossible to fully take the number of times of a rolling pass from the whole cross section decrement in a rail pressure Nobu process, and rail shaping becoming difficult.

[0030]About the time between paths, it is required to be 10 or less seconds. Big-and-rough-izing of the crystal grain according [ a hot austenite grain ] to union of contiguity grains, mixed-grain-size-izing, and what is called grain growth happen easily. When usual reverse rolling and continuous rolling also have a large distance between rolling mills, the time between paths becomes long with about 20 to 60 seconds, and recovery of a strain, recrystallization, and also grain growth of the austenite grain rolled in the meantime happen. In the high carbon component system of this invention, in order to complete recrystallization immediately after rolling, grain growth arises between the time between paths as shown previously, and the effect which became a fine grain by recrystallization is reduced. If the time between paths exceeds 10 seconds, it becomes so large that it becomes impossible to overlook the influence of the grain growth between this path, the grain-refining effect of the austenite grain by rolling recrystallization decreases, and the purpose cannot be attained. As stated previously, the continuous rolling more than a two pass is required at least from a viewpoint of grain refining by repetition of recrystallization.

[0031]The reason for the cooling rate in a rail surface cooling to 800-950 ** in s in 0.5-50 ** /continuously after completing the above rolling is explained. Previously, when the grain growth of the austenite between rolling passes exceeded after-rolling 10 seconds, it described that it becomes impossible to overlook the influence, but an action also with same grain growth of the austenite after the end of rolling is taken. Control of grain growth is attained by reducing the temperature of austenite like reverse middle rolling described previously at this time.

Therefore, it is necessary to avoid the influence of the temperature to grain growth because the cooling rate in a rail surface cools to 800-950 ** in s in 0.5-50 ** /. Although the cooling method in this case is not especially limited, either, in order to secure a required cooling rate, the method of spraying a gaseous mixture including a fluid or mist, such as water, is preferred.
[0032]Accelerated cooling is performed when raising radiational cooling or intensity further. The reason for limitation of accelerated cooling is explained. The austenite region of steel and not less than at least 700 ** are required for cooling starting temperature, and when less than this, it cannot perform effective transformation strengthening. s is required for a cooling rate in 2-15 ** /from the temperature requirement in connection with the transformation of steel, i.e., the temperature of 700 or more, before 500 **, and only transformation strengthening whose difference is not remarkable is obtained [ ** / // less than 2 / radiational cooling ] in s. If s is exceeded in 15 ** /, mixing of abnormal structure, such as bainite or martensite, will be caused, and abrasion resistance and toughness will be checked remarkably. Although the cooling method in this case is not especially limited, either, the method of spraying a gaseous mixture including a gas or mist, such as air, from a controllable viewpoint of a cooling rate is preferred.
[0033]
[Example]The example of this invention is shown below. Middle rolling which consists of three paths on the conditions which show the sample offering steel which consists of a chemical entity shown in Table 1 in Table 2 after rough rolling, and finishing rolling were performed, cooling immediately after rolling was performed on the conditions shown in Table 3, and heat treatment and cooling for high-intensity-izing were performed on the conditions shown in radiational cooling or Table 4. Heat treatment which shows cooling after rolling shown in cooling under middle rolling shown in Table 2 and Table 3 in Table 4 using the method of spraying water, and cooling used the method of spraying air.
[0034]The mechanical properties of rail steel in this invention method and comparison method at the time of manufacturing a rail combining the heat treatment cooling conditions for the steel composition shown in Table 4, a rolled bar affair, the cooling conditions immediately after rolling, and high-intensity-izing from Table 1 are shown in Table 5. In this invention method, although the intensity of a rail changes with a steel composition and cooling conditions, it turns out that a ductility value and a toughness value show a remarkable high value as compared with it of a comparison method.
[0035]
[Table 1]

| 鋼 | C | Si | Mn | Cr | Mo | V | Nb | Ti |
|---|---|---|---|---|---|---|---|---|
| A | 0.65 | 0.20 | 0.90 | | | | | |
| B | 0.80 | 0.50 | 1.00 | 0.20 | | 0.05 | | |
| C | 0.75 | 0.80 | 0.80 | 0.50 | | | 0.02 | 0.01 |
| D | 0.80 | 0.25 | 0.90 | 1.20 | 0.20 | | | |
| E | 0.95 | 0.20 | 0.80 | | | | | |

[0036]

[Table 2]

| | 符号 | 中間圧延条件 | | 仕上げ圧延条件 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 開始温度℃ | 終了温度℃ | 1パス目 | | パス間秒 | 2パス目 | | パス間秒 | 3パス目 | |
| | | | | 温度℃ | 圧下率% | | 温度℃ | 圧下率% | | 温度℃ | 圧下率% |
| 本発明法 | A | 1050 | 1010 | 1000 | 25 | 1 | 1000 | 5 | 1 | 1000 | 15 |
| | b | 1010 | 970 | 950 | 30 | 1 | 950 | 5 | 5 | 950 | 10 |
| | c | 1010 | 970 | 950 | 30 | 1 | 950 | 10 | - | - | - |
| | d | 940 | 900 | 880 | 15 | 1 | 880 | 5 | 7 | 875 | 10 |
| 比較法 | e | 1110 | 1070 | 950 | 30 | 1 | 950 | 2 | - | - | - |
| | f | 1110 | 1070 | 1000 | 25 | 1 | 1000 | 5 | 25 | 980 | 15 |
| | g | 1110 | 1070 | 1000 | 25 | 20 | 985 | 15 | 20 | 970 | 5 |

[0037]

[Table 3]

| 符号 | 冷却開始温度 ℃ | 冷却速度 ℃/s |
|---|---|---|
| i | 1000 | 40 |
| ii | 950 | 20 |
| iii | 850 | 0.5 |

[0038]

[Table 4]

| 符号 | 冷却開始温度 ℃ | 冷却速度 ℃/s |
|---|---|---|
| I | 800 | 4 |
| II | 800 | 6 |
| III | 720 | 10 |
| IV | 800 | 1 |

[0039]

[Table 5]

| | 符号 | 鋼 | 圧延方法 | 圧延直後冷却方法 | 熱処理冷却方法 | 引張り強さ (MPa) | 伸び (%) | $_{2}U_{E+20}$ (J/cm²) |
|---|---|---|---|---|---|---|---|---|
| 本発明法 | 1 | A | a | i | 放冷 | 925 | 16 | 28 |
| | 2 | B | b | ii | I | 1210 | 17 | 35 |
| | 3 | B | b | ii | III | 1280 | 18 | 44 |
| | 4 | D | b | ii | 放冷 | 1095 | 14 | 30 |
| | 5 | C | c | ii | II | 1275 | 16 | 32 |
| | 6 | B | d | iii | III | 1260 | 18 | 46 |
| 比較法 | 7 | A | e | — | 放冷 | 940 | 12 | 18 |
| | 8 | B | f | — | IV | 1020 | 13 | 20 |
| | 9 | D | g | — | 放冷 | 1110 | 12 | 18 |

[0040]

[Effect of the Invention]According to this invention method, as mentioned above, the pearlite texture of a fine grain can be obtained and, in addition to abrasion resistance, the rail which raised toughness can be manufactured.

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[Translation done.]